VOL. 13, NO. 1, JANUARY 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

ANALYSIS OF THE LURING CHARACTERISTICS OF PHOTOTACTIC FISHES UNDER LED ILLUMINATION IN WATER

Dongwook Ko, Bongjun Gu and Jongbok Kim
Department of Materials Science and Engineering, Kumoh National Institute of Technology, Daehak-ro, Gumi, Korea
E-Mail: jbkim@kumoh.ac.kr

ABSTRACT

The marine pollution problem in the offshore is becoming more serious due to the expansion of the marine ranching business and the increase in the artificial feed consumption. In order to solve this problem, it is essential to develop eco-friendly culture approaches that can run marine ranching systems without artificial feeds. In this study, we investigated the possibility of growing the fishes without artificial feeds by luring phototactic fishes into the farm using LED (light emitting device) illumination in water. Specifically, we examined the luring capability of underwater LED light for young filefishes to the desired place and analyzed the luring time depending on the wavelength and intensity of underwater LED, night and day, etc. As a result, it was observed that young filefishes responded sensitively to blue LEDs rather than white LEDs and the luring time was independent on the intensity of underwater LEDs in this experimental scale. In addition, while LED light attracted young filefishes into LED area at day time, the filefishes were distant from the underwater LEDs at night time. In conclusion, we expect that underwater LEDs can attract phototactic fishes into the marine ranches and farm, resulting in the fishes to be fed without artificial feeds.

Keywords: fish feeding system, natural feeding, underwater LED, phototactic fish, filefish.

INTRODUCTION

The seafood is a representative complete food with the protein and the essential nutrients, so its demand in the world continues to increase every year. The fishery industry is trying various fishing methods such as deep-sea fishing and off-shore fishing in order to increase the production of seafood and satisfy the increasing need for seafood. However, due to the decrease in the population engaged in fishing and the changes in the fishery environment in the coastal waters, catches are showing a decreasing tendency and more innovative approaches are required. One of innovative approaches is the coastal sea ranching project, which artificially provides the optimal environment for the fishes [1-2]. The sea ranch business has its ultimate purpose of directly managing the fishery resources suitable for the sea area by the fishermen, generating income and supplying the high quality seafood to the market. However, due to the continuous expansion of the sea ranches and farms, the problem of pollution in the marine environment has been raised.

We are able to consider the underwater LED-based sea ranching/farming system adopting the principle of the light luring-based fish catching method as a approach to suppress the marine pollution due to the artificial feed as well as to smoothly construct the offshore sea ranch and farm [3-5]. In other words, a natural food supply system can be constructed by attracting fishes far away from sea ranches or marine farms using the principle of luring fishes with the light. Generally, light-luring fishing methods adopt the incandescent lamps, halogen lamps, and metal halide lamps, which are commonly used to catch the cuttlefish, rockfish, and blowfish. The principle for luring the fishes by the light can be divided into two major mechanisms [6-7]. The first is that the fish species directly respond to the light of the preferred wavelength and gather in the direction of light. Secondly, the light grows the plankton, which is the primary food of the fish, gathering the fishes for the ingestion. In particular, the studies on the fishes to respond to the light of wavelengths preferred by fish species have been mainly carried out, indicating the squid likes blue light [8-9] and the rockfish loves white light [10-11]. However, because such light to gather the fishes is made of metal halide, halogen, incandescent material, it generates energy consumption problem, high reflection issue at the water surface and poor water permeability. To overcome these problems, energy-efficient LEDs (light emitting devices), especially the LEDs with water-resistant function, have been developed [12-14].

In this study, we examined the luring characteristics of phototactic fish species under the illumination of the underwater LEDs and investigated the effect of LED intensity, day and night. The underwater LEDs could efficiently lure the phototatic fishes, expecting to construct eco-friendly marine ranching and aquaculture system.

EXPERIMENTAL METHODS

In order to observe the luring characteristics of phototatic fishes under LED illumination in water, we constructed a small sea ranch environment using a water tank of 50 cm x 50 cm x 100 cm size and choosed a young filefish (*Stephanolepis cirrhifer*) as phototatic fish specie. The filefishes were used for the experiment after one day of environmental adaptation process. Each experiment was carried out with different set of filefishes to avoid stress effect to the fishes. We used white LEDs and blue LEDs as the underwater LEDs, and the LEDs was installed vertically to the water bath.

In order to observe the luring characteristics of the filefishes in each condition, all the filefishes (100 fishes) were placed on one side of the tank. Then, we measured the time to gather them by 25%, 50% and 75% in the underwater LED region after LED lights were

turned on. The movement of the fishes was judged based on the boundary line drawn in the center of the tank. The luring characteristics were analyzed at day time and night time. We carried out the experiment from 1:00 pm for day time test and from 9:00 pm for night time test. The experiment to check the luring characteristics depending on LED power was carried out by adjusting the number of LED chips. The total number of LED chips was 38, and the number of LED chips were controlled to 20 (52%), 26 (68%), 30 (78%) and 32 (84%). Then, we measured the gathering time of filefishes by 25%, 50%, 75% to the underwater LED area after turning on the underwater LED light with controlled output power.

RESULTS AND DISCUSSIONS

In order to examine the luring effect of phototatic filefishes in the illumination of underwater LEDs, a small ocean ranching environment was established as shown in Figure-1 a. Then, as shown in Figure 1 b, LED light was turned on at one side of the water tank. It was judged whether or not the filefishes was moved by the center line of the water tank. First, we investigated the luring characteristics of the young filesfishes with the size of 1 cm under the illumination of white and blue LEDs. Because it was difficult to judge the movement of the fishes with the LEDs parallel to the water tank due to irradiating the entire water tank, the experiments were carried out with the LEDs perpendicular to the water tank (Figure-1 b).

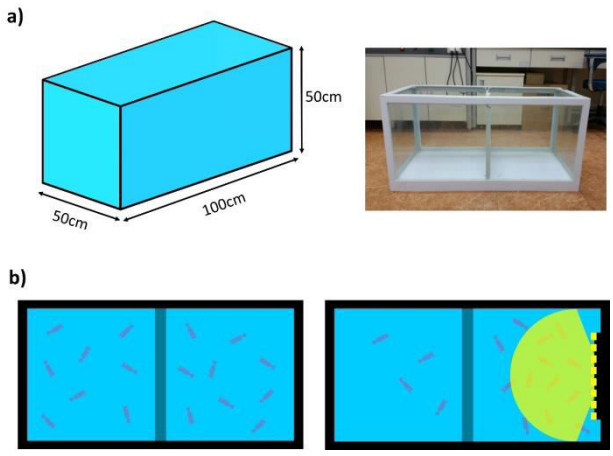

Figure-1. a) Small marine ranch environment and b) the schematic to lure the phototatic fishes with LED light illumination.

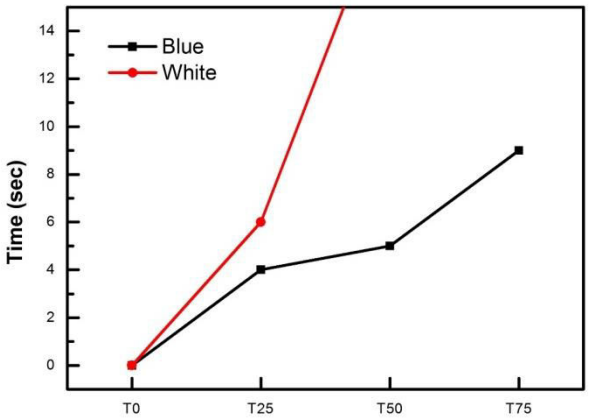

Figure-2. The luring characteristics under the illumination of white and blue LEDs depending on the exposure time.

Figure-2 shows the time taken for the young filefishes to reach the LED light region depending on the wavelength of the light source. In the case of white underwater LEDs, it took about 6 seconds to collect 25% of the filefishes in the LED area, and more than 50% of the filefishes did not gather in the LED area regardless of LED illumination time. On the other hand, in the case of blue LEDs, 25% of the filefishes took 4 seconds to collect in the LED area, 50% of the filefishes collected in 5 seconds and 75% of the fishes collected in 8 seconds. Therefore, it was confirmed that the filefishes selected as the phototatic fish in this experiment were more sensitive to the blue LED than the white LED in this experiment.

Then, with a blue LED the filefishes are more sensitive and the filefishes with the size of 3 cm in average, we examined the dependence of luring property of filefishes on the day and at night. Figure 3 shows luring time for the young filefishes by 25%, 50% and 75% at the day time and night time. As shown in Figure-3, while the filefishes were gathered toward the blue LED light source within 100 seconds in the day time, they escaped toward the opposite region of the light source at night time. Specifically, it took about 5 seconds for 25% filefishes to move toward the opposite side of the light source when the LED lighted up during the night time. Also, we observed the filefishes of 50% escaped from the light source in about 20 seconds and the filefishes of 75% needed 160 seconds to escape. We speculates it is because lights interfered with their sleep at night, indicating it is necessary to use underwater LED only during the daytime in order to attract the filefishes into the sea ranch and farm.

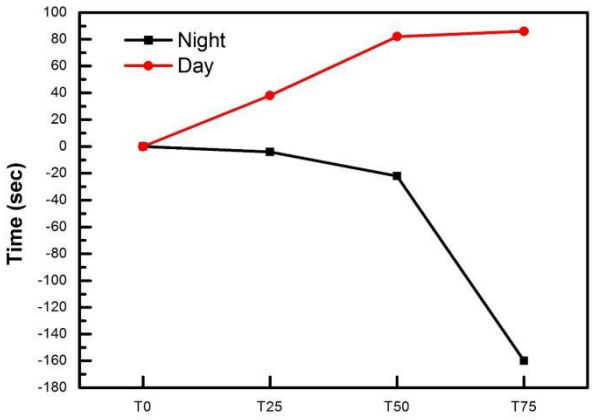

Figure-3. The luring characteristics under the blue LED illumination in day time and at night.

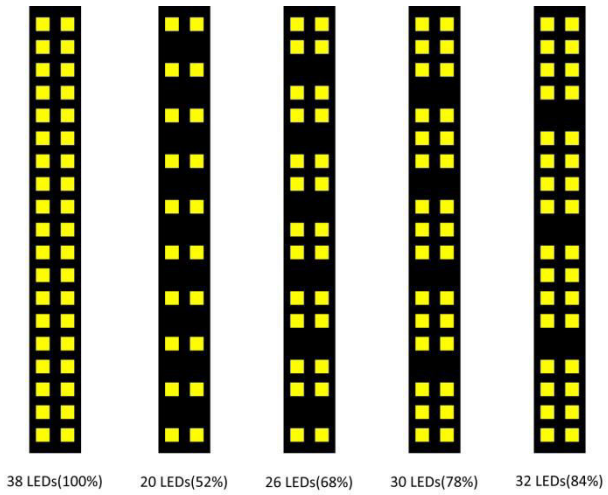

Figure-4. Modulation scheme of output power of blue LED.

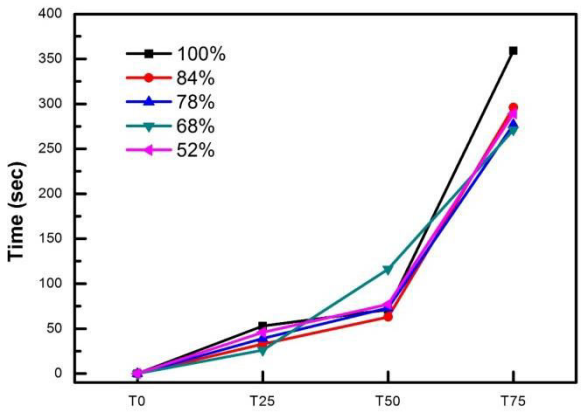

Figure-5. The luring time depending on the output power of blue LEDs.

Finally, to observe the luring characteristics of the filefishes depending on the output power of the LED light source, the number of LED chips in the LED module was changed as shown in Figure-4. Specifically, after setting all 38 LED chips at 100%, the LED output was adjusted to 84%, 78%, 68%, and 52% by controlling the number of chips that are turned on, followed by examining the luring property. Figure-5 shows the luring time depending on the output of underwater LED. As shown in the Figure-5, when the output power of the underwater LED was limited to 52%, it took 46 seconds to gather the 25% filefishes, 77 seconds for 50% filefishes and 289 seconds for 75% filefishes. Then, even when the output of the underwater LED was changed to 68%, 78%, 84%, and 100%, the luring time was similar to that in 52% output of the underwater LED. We speculate it was from too small marine rich tank. Because the ranch for the experiment was very small compared to the actual ranch, the LED light reached at the end of the tank regardless of output power, resulting in similar luring characteristics regardless of output power.

CONCLUSIONS

We observed the luring characteristics of the phototatic fishes with the young filefishes. Based on the testing results for white and blue underwater LEDs, we recognized the filefishes responds more sensitively to the blue LEDs. While the filefishes loves the LED light at the daytime, they escape from the light source at the night. However, the output power of LED lights does not affect luring characteristics. It is speculated that water tank is so small that the light always reaches at the end of the water tank regardless of LED power. In conclusion, we could effectively lure the filefishes to the desired region by using underwater LEDs, expecting to be applied to eco-friendly marine ranches and farms to grow the fishes without the artificial feed.

ACKNOWLEDGEMENTS

This paper was supported by Research Fund, Kumoh National Institute of Technology.

REFERENCES

[1] Yoon B. -S., Yoon S. -C., Lee S. -I, Kim J. -B., Yang J. -H, Park J. -H., Choi Y. -M. and Park J. -H. 2011. Community Structure of Demersal Organisms Caught by Otter Trawl Survey in the Uljin Marine Ranching Area, Korean Journal of Fisheries and Aquatic Sciences. 44, pp. 506-515.

[2] Yoon B. -S., Park J. -H., Sohn M. H., Yang J. H., Yoon S. C. and Choi Y. M. 2013. Community Structure and Distribution Pattern of the Pleuronectiform Fishes in the Uljin Marine Ranching Area, Korean Journal of Fisheries and Aquatic Sciences. 46, pp. 413-423.

[3] Park J. -S., Kim S. -J. and Kim M. -K. 1997. A study on the Leading Effect of Fish Attracting Lamps on Fish schools into a set-net, Bulletin of Korean Society of Fisheries Technology. 33, pp. 311-320.

[4] Choi S. -J. and Arankawa H. 2001. Relationship between the Catch of Squid, Todarodes pacificus STEENSTRUP, according to the Jigging Depth of Hooks and underwater illumination in Squid Jigging Boat., Journal of Korean Fisheries Society. 34, pp. 624-631.

[5] Choi S. J. 2008. Comparison of Radiation Characteristics and Radiant Quantities per unit Electrical Power between High Luminance Light Emitting Diode and Fishing Lamp Light Source. Journal of Korean Fisheries Society. 41, pp. 511-517.

[6] Inoue M. 1978. Fish Behaviour and Fishing Method. Kouseisha-kouseikaku, Tokyo.

[7] An Y. -I. and J. H. -G. 2011. Catching efficiency of Led fishing lamp and behavioral reaction of common squid Todarodes pacificus to the shadow section of color LED light. Journal of the Korean Society of Fisheries Technology. 47, pp. 183-193.

[8] An Y. -I., Jeong H. -G., Jung B. -M. 2009. Behavioral reaction of common squid Todarodes pacificus to different colors of LED Light. Journal of the Korean Society of Fisheries Technology. 45, pp. 135-143.

[9] Jeong H., Yoo S., Lee J. and An. Y. -I. 2013. The retinular responses of common squid Todarodes pacificus for energy efficient fishing lamp using LED. Renewable Energy. 54, pp. 101-104.

[10] Yang Y. -R. 1981. Phototaxis of Fish 4. Response of gray Rock Cod and Cat Shark to the White Lights. Bulletin of Korean Society of Fisheries Technology. 14, pp. 59-65.

[11] Yang Y. -R. 1983. Response of Gray Rock Cod to the Colored Lights. Bulletin of Korean Fisheries Society. 16, pp. 330-334.

[12] Park S. -W., Bae B. -S., An H. -C., Lee J. -W. and Seo D. -O. 2002. Transmittance Characteristics by candlepower of Incandescent Lamp. Bulletin of Korean Society of Fisheries Technology. 38, pp. 293-299.

[13] Choi S. J. 2006. Radiation and Underwater Transmission Characteristics of a High-Luminance Light-emitting Diode as the Light Source for Fishing Lamps. Journal of Korean Fisheries Society. 39, pp. 480-486.

[14] Choi S. -K., Kim S. -J., Park D. -W., Kil G. -S., Choi C. -Y. and Song. S. -B. 2010. Design and Fabrication of an Energy Saving LED-Fishing Lamp. Journal of the Korean Marine Engineering. 34, pp. 515-521.